Thoracoscopic partial pericardiectomy for the treatment of pericardial effusion in dogs

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ABSTRACT

Thoracoscopy is a minimally invasive imaging method used in the imaging of the thoracic cavity. In comparison with thoracotomy, thoracoscopy provides better visualization of even the smallest lesions localized in the thoracic cavity. With the use of thoracoscopy, the operation stress in the patient and tissue trauma are reduced, and operating time is shortened. The aim of this study was to evaluate 20 dogs with severe pericardial effusion, which manifested as severe circulation disorder and respiratory distress. The patients determined with pericardial effusion as a result of radiographic and echocardiographic examinations were applied with partial pericardiectomy to achieve permanent health and it was decided to apply this with the minimally invasive thoracoscopic method. The paraxiphoid-transdiaphragmatic approach was applied to the first ten patients and the intercostal approach to the latter. Applicability of thoracoscopic partial pericardiectomy, advantages compared to open surgery, differences between two approach techniques, disadvantages, complications, and success rates were evaluated. It was concluded that this procedure was a successful procedure for dogs and the transdiaphragmatic approach was more useful. In conclusion, thoracoscopic partial pericardiectomy was determined to be easy to apply and more advantageous than open thoracotomy operations.

Introduction

Pericardial effusion (PE), which is defined as abnormal fluid accumulation within the pericardial sac (7, 11), is a well-described clinical condition in dogs. The increase in pericardial fluid levels leads to elevate intrapericardial pressure, and when this pressure increases to a level greater than or equal to right ventricular pressure, cardiac tamponade occurs. Right-sided congestive heart failure and reduced cardiac tamponade are consistent with clinical signs. Studies shows that exercise intolerance (70%), muffled heart sound (60%) and ascites (50%) are common clinical findings (16, 23). Pericardiocentesis is the most effective and fastest way to resolve clinical symptoms and is often performed as an emergency procedure. Pericardial fluid obtained by pericardiocentesis may also be helpful for diagnosis (9, 13).

Pericardial effusion is idiopathic or caused by a neoplastic process (mesothelioma), the most common acquired pericardial disease in dogs (15, 16). In the majority of affected cases, pericardiocentesis is initially indicated for fast patient stabilization (11). Pericardiectomy is indicated in recurrent PE of idiopathic or neoplastic origin to facilitate drainage into the pleural space. In this way, it reduces intrapericardial pressure and cardiac compression (13, 25). Prolonged survival is possible ensuing pericardiectomy.

Traditionally, pericardiectomy is performed with open thoracic surgery, either by median sternotomy or via an intercostal approach. This kind of procedure is often limited to more specific applications and may be rejected by owners due to the associated costs and invasive methods (1, 2).

Thoracic access to the thoracic cavity is used in lateral intercostal, transdiaphragmatic or paraxiphoid, and cranial or thoracic inlet entrance areas. The advantages and disadvantages of the first two entry zones compared to each other are completely related to the experience of the surgeon. Thoracic inlet is a technique taken from the human surgical technique and has a limited use for access to the cranial mediastinum (14).

Thoracoscopic partial pericardiectomy has the additional advantage of offering better visualization than conventional open thoracotomy by improving illumination and magnification to previously unapproachable areas (27). It is also associated with less postoperative pain and lower morbidity. Previous studies have shown thoracoscopic partial pericardiectomy in dogs has less pain and the recovery time of patients is much shorter (18, 26). Thoracoscopic surgery is associated with several advantages compared with open thoracotomy, including reduced postoperative pain, faster return to function, and reduced wound complications (24). It can be used in many surgical procedures such as lobectomy, ductus thoracicus ligation, and removal of pulmonary masses (3, 5, 18, 19, 22, 24).

Thoracoscopic partial pericardiectomy has the added benefit of offering better visualization than traditional open thoracotomy by improving illumination and magnification of areas inaccessible with other methods. It is also associated with less postoperative pain and lower morbidity (2, 8, 26). The aim of this study was to determine the advantages, complications, and success rates of thoracoscopic partial pericardiectomy applied to dogs.

Materials and Method

The study sample was formed of 20 dogs of different ages, sex, and breeds, determined with pericardial effusion on radiographic and echocardiographic examinations. In the clinical examination of the dogs, respiratory distress, anorexia, and cough were determined. Preoperatively, serum biochemistry and full blood analyses were performed together with clotting profile, urine analysis, pericardial effusion fluid sample cytology, and thorax and abdomen radiography, ultrasonography, and echocardiography evaluations.

Radiography was performed in latero-lateral and ventro-dorsal planes to dogs and vertebral heart scale (VHS) evaluations were made. Patients with high VHS scores were applied with echocardiographic examinations and left and right parasternal long axis images were taken. An anechoic space between pericardia and epicardium was accepted as proof of pericardial effusion. Patients were intubated, connected to a mechanical ventilator, and laid in dorsal recumbence. Radiographs were taken using an digital radiography device (Dynamic X-Ray, Türkiye), with 1000 milliamps equivalent to 600 mA HF frequency, and 150 kV power. Patients observed with cardiomegaly underwent echocardiographic examination. An evaluation was made of pericardial effusion from the left and right window, the cause, and heart diseases.

Echocardiographic examinations were made with 2.5, 5, 7 MHz multifrequency probes in color Doppler machine (ESAOTE AU5, Italy).

A endoscopic camera (Kalz Storz Telecam SL II, Germany), endoscopic light source (Kalz Storz Xenon Nova 175, Germany), aspiration machine (Kalz Storz Vetpump 2, Germany), Hopkins II, 0^0, rigid, 30 mm length 5 mm diameter telescope (Kalz Storz 62046 AA, Germany), were used to access the abdominal cavity for the telescope and the thoracoscopic surgical equipment used were a 6 mm diameter, 10.5 cm long Ternamian Endotip 3 spiral trocar (Kalz Storz 60160 MTR, Germany), thoracoscopic scissors (Kalz Storz 34310 MA, Germany), grasper forceps (Kalz Storz 33310 ME, Germany) and a suction catheter (Kalz Storz 26173 BN, Germany).

All animals received pre-emptive analgesia with morphine HCl (0.12 mg/kg), and general anesthesia was provided with propofol (4 mg/kg, IV) and isoflurane (2-4%, using cuffed endotracheal tubes), setting the ventilator to “pressure-controlled ventilation” mode with an inspiratory pressure value of 10 cm H_2O, with respiratory rates of 16 breaths/minute. PEEP (positive end-expiratory pressure) mode was activated and was set to 2 cm H_2O for recruitment maneuver and to prevent atelectasis. All the dogs recovered from anesthesia in the intensive care unit, received fluids, analgesics, oxygen and were monitored for hypothermia, pain and dyspnea. Postoperatively advanced ampicillin (30 mg/kg IV TID), Tramadol (4 mg/kg SC QID) and Dipyron (25 mg/kg SC TID) were administered. Analgesics were administered to all the dogs at 6 and 12 hours after surgery.

The thoracoscopic partial pericardiectomy procedure was applied with the paraxiphoid-trandiaphragmatic approach to the first ten patients and with the intercostal approach to the remaining ten (10). The first trocar was positioned immediately below the xiphoidal cartilage, directed to the thorax and when the thoracic cavity was reached, the trocar valve was opened and pneumothorax was created. The telescope was advanced to the thoracic cavity from this port. The first operative toll was introduced from the left 6^{th} or 7^{th} intercostal space and the second operative toll was introduced from the left 9^{th} or 10^{th} intercostal space under telescope guidance.

The pericardium was grasped with grasping forceps. In some cases, pericardium was too tight to grasp because of effusion, so in these cases some of the fluid was drained with pericardiocentesis. The samples obtained were sent

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to the pathology laboratory for cytological evaluation. A 1 cm diameter incision was made in the pericardia with thoracoscopic scissors. The fluid discharged to the pleural cavity was drained with a suction catheter. A piece approximately 4x4 cm in size was taken from the pericardium. The telescope was then inserted from the intercostal ports and the space between the pericardium and epicardium was examined for any signs of neoplasia. After completion of the procedure, all the equipment was removed, a thoracic drain was placed in the 9th or 10th intercostal space and thoracic incision sites were closed with simple interrupted sutures using nonabsorbable polypropylene (prolene) 2/0 monofilament suture material. The thoracic drain was connected with a 3-way stopcock. Free air in the thoracic cavity was evacuated with a 3-way stopcock and negative pressure was achieved. All the dogs received a single dose of meloxicam (0,2 mg/kg, Meloxicam, Bavet, Türkiye) subcutaneously immediately after the procedure.

All dogs were examined at 3, 6, 12 and 24 months after the operation. Radiographic and echocardiographic examinations were repeated in patients on these dates. If the patient could not attend the examination, the owner was contacted by telephone.

Results

The evaluation was made of 20 dogs, comprising 12 females and 8 males with a mean age of 7 years (range, 2-12 years). The dog breeds were West Highland white terrier (WHWT) (*n*= 4), German Shepherd (*n*= 3), Golden Retriever (*n*= 2), Kangal Shepherd (*n*= 1), Miniature Pinscher (*n*= 1), Pekingese (*n*= 1), Maltese Terrier (*n*= 1), Boxer (*n*= 1) and street mixed breed (SMB) (*n*= 6).

It was learned in the anamnesis that 5 patients with cough and respiratory stress were diagnosed with asthma in 4 (nos. 2, 6, 11, 17) and heart failure in 1 (no. 7), and medical treatment was performed. One case (no. 15) had received treatment for 3 weeks for a diagnosis of lymphoma. Except for one case (no. 15) with a low platelet count, no abnormalities were determined in the preoperative blood analysis. In the same patient, growth of the intra-abdominal lymph nodes and increased spleen dimensions were noticed on ultrasonography.

On the echocardiography examination, severe pericardial effusion was determined in 12 dogs and cardiac tamponade in 5 (Figure 1). In case number 19 a neoplasia suspected lesion was seen in the right atrium (Figure 2), and in case number 7, dilated cardiomyopathy (DCM) was seen together with pericardial effusion.

The transdiaphragmatic approach was used in ten randomly selected cases and the intercostal approach was used in the other ten cases (Figure 3). In one patient, the close proximity of the lungs to the placement of the camera and thoracoscopic instruments providing the

Figure 1. Severe pericardial effusion and cardiac tamponade image (arrow) in ultrasonographic examination of case number 14.

Figure 2. Left window, long axis four chamber view, myocardial neoplasia in the right atrium (arrow), case 13.

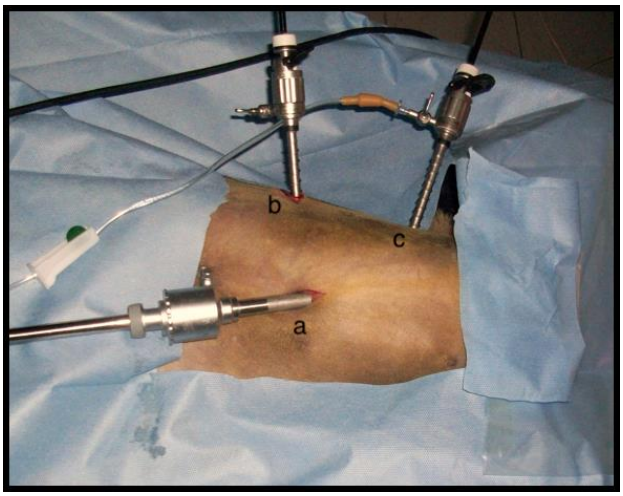

Figure 3. The position of trocar units for thoracoscopic partial pericardiectomy operation of case number 11. Paraxiphoid port used for telescope entrance (a). Other ports in left 6th (c) and 10th intercostal space (b) used for thoracoscopic equipment entry.

visualization angle necessary for the operation prevented comfortable work. Therefore, the intercostal approach was converted to the paraxiphoid trans-diaphragmatic approach because of poor visualization of the working area. Inflammatory pericardial thickening was seen in 5 of 20 cases. In three cases thickening in the parietal pleura was also seen (Figure 4). In case number 3, a mass originating from the myocardium was seen and the pathology report was of rhabdomyosarcoma (Figure 5). In case number 15, thoracic lymph nodes were enlarged, and in case number 16, an abscess approximately 3 cm in diameter was seen in the left cranial lung lobe. Patients with confirmed negative pressure were hospitalized and monitored for one day then discharged from the hospital. In one case (number 9) hypothermia and dyspnea were observed and the patient was kept in an oxygen tent for 48 hours. After the dog recovered, it was discharged from the hospital. In case no. 5, pulmonary laceration occurred through surgeon error, so partial pulmonary lobectomy and partial pericardiectomy were applied. The case was not withdrawn from the study so that the complication could be discussed. The operating time was recorded as mean 32 mins for the paraxiphoid-transdiaphragmatic approach and mean 48 mins for the intercostal approach.

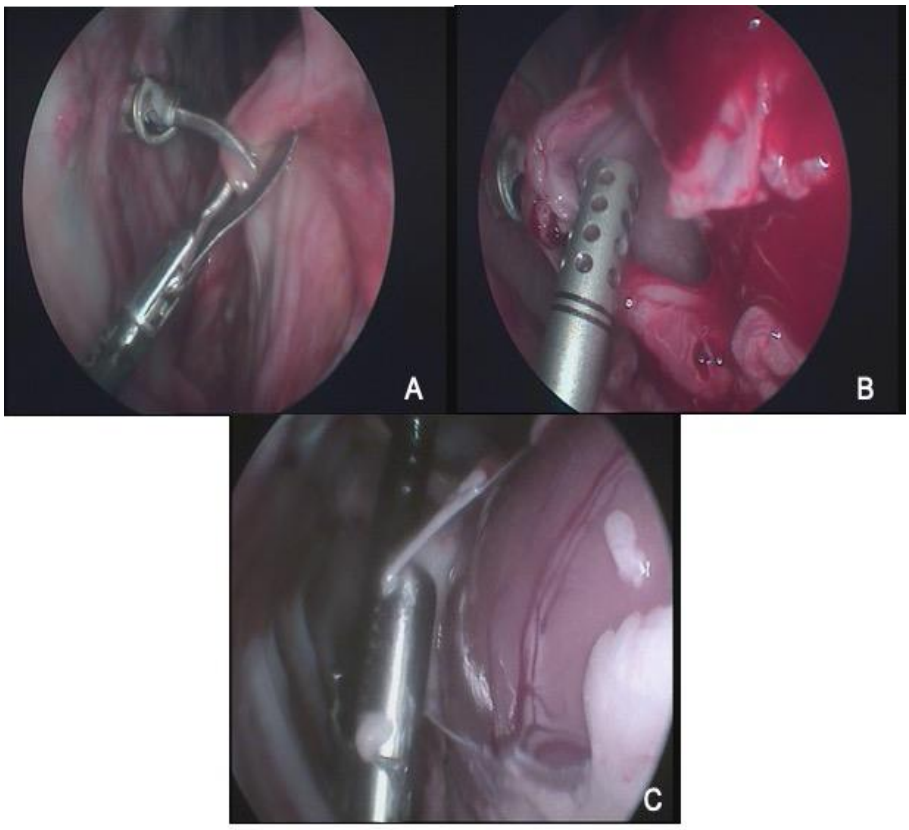

Figure 4. A and B = Severe thickening in parietal pleura and pericardium (case 2 and 13). C=A normal pericardium (case 10).

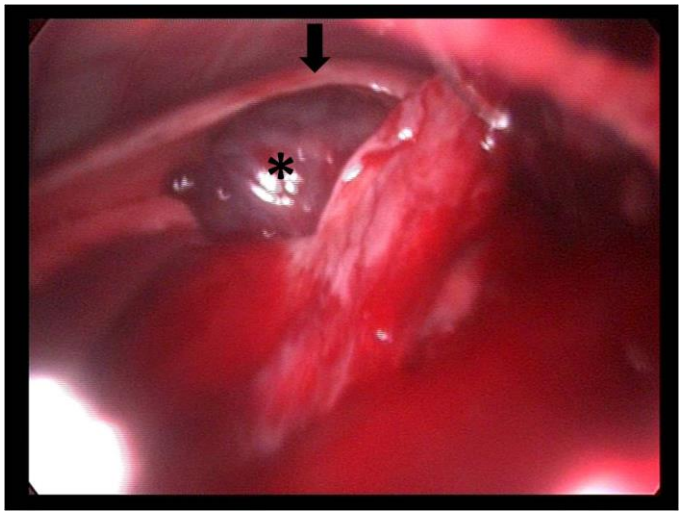

Figure 5. Case 3, Rhabdomyosarcoma. Pericardium (arrow), tumor (*).

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Table 1. Echocardiography results, thoracoscopic approach methods, findings and outcomes of cases.

Case	Breed	Age	Echocardiography results	Thoracoscopic approach	Thoracoscopic findings	Outcome
1	Golden Retriever	4	Severe pericardial effusion, cardiac output	PTD	Thoracic cavity, pleura and pericardium were normal	No complications
2	Maltese terrier	2	Pericardial and pleural effusion	PTD	Pleural and pericardial thickening	No complications were seen
3	Pekingese	8	Severe pericardial effusion, cardiac output pleural effusion	I	Mass formation	No complications were seen. The patient died due to pulmonary metastases at 4 months postoperatively
4	Boxer	5	Pericardial and pleural effusion	I	Pleural and pericardial thickening	No complications were seen
5	Miniature Pinscher	5	Pericardial effusion	I	Thoracic cavity, pleura and pericardium were normal	Pulmonary laceration occurred during procedure, then converted to open surgery
6	SMB	7	Pericardial effusion	First I, later PTD	Thoracic cavity, pleura and pericardium were normal	No complications were seen
7	WHWT	6	Pericardial effusion, pleural effusion, Dilate cardiomyopathy	PTD	Thoracic cavity, pleura and pericardium were normal	No complications were seen. The patient died due to kidney failure at 8 months postoperatively.
8	SMB	9	Pericardial effusion	PTD	Thoracic cavity, pleura and pericardium were normal	No complications were seen.
9	Golden Retriever	12	Pericardial effusion	I	Pericardial thickening	Respiratory stress developed after surgery, respiration stabilized after six hours
10	SMB	2	Pericardial effusion	I	Thoracic cavity, pleura and pericardium were normal	No complications were seen.
11	SMB	3	Severe pericardial effusion, cardiac output	PTD	Thoracic cavity, pleura and pericardium were normal	No complications. The patient died when struck by a car after 1 year
12	German Shepherd	4	Pericardial and pleural effusion	I	Thoracic cavity, pleura and pericardium were normal	No complications.
13	Kangal Shepherd	7	Pericardial and pleural effusion, mass-like lesion in left ventriculi	PTD	Pleura and Pericardial thickening	No complications.
14	German Shepherd	10	Severe pericardial effusion, cardiac output	PTD	Thoracic cavity, pleura and pericardium were normal	No complications. Hypothermia and hypoxia but stabilized after 4 hours
15	WHWT	9	Pericardial and pleural effusion	I	Thoracic lymph nodes were enlarged	No complications.
16	SMB	11	Pericardial and pleural effusion	I	Abscess in cranial lung lobe	No complications.
17	WHWT	12	Pericardial effusion	I	Thoracic cavity, pleura and pericardium were normal	No complications.
18	German Shepherd	9	Pericardial effusion	PDT	Thoracic cavity, pleura and pericardium were normal	No complications.
19	SMB	8	Severe pericardial effusion, cardiac output	PDT	Pericardial thickening	No complications.
20	WHWT	6	Pericardial effusion	PDT	Thoracic cavity, pleura and pericardium were normal	Pleural effusion recurrence at 8 months postoperatively and the patient died

I: Intercostal approach.
PDT: Trans- diaphragmatic approach.
SMB: Street mix breed.
West Highland white terrier: WHWT.

In four cases, the dogs came from another city and follow-up was made with telephone calls to the owners and the well-being of the dogs was confirmed. One year after the operation, one dog (case number 11) died when struck by a car, and one dog (case number 7) died from kidney failure. Case number 20 was brought to the clinic after eight months with severe respiratory distress. Ultrasonographic examination showed a reoccurrence of pericardial effusion and the dog died after that day.

The only complications seen were lung laceration in case no. 5, postoperative hypothermia and hypoxia in case no.9, and a recurrence of pericardial effusion because of closure of the opened pericardial window in case no. 20.

Discussion and Conclusion

The common goal of all treatment methods in pericardial effusion is to resolve it, determine its etiology, and avoid recurrences, all with the least possible morbidity and mortality. There are three fundamental surgical possibilities: complete pericardiectomy, subxiphoid pericardiotomy and pericardial window (thoracotomic or thoracoscopic approach). The application times of the techniques are generally close to each other and the thoracotomy takes a little longer. The possibility of thoroughly exploring the pericardial cavity and pleural space and on the possibility of obtaining sufficient study material is effective in choosing a technique (8, 12). A thoracoscopic partial pericardiectomy is a very effective operation for the elimination of the clinical symptoms of pericardial effusion (14). Thoracoscopic partial pericardiectomy has a better diagnostic capacity in these aspects than the other techniques, as it enables to explore the pleural cavity thoroughly and visualize and obtain samples of suspicious lesions and associated effusions (17).

Jacksons et al. (14) reported that opening a 4-5 cm diameter pericardial window is sufficient to eliminate clinical symptoms in thoracic partial pericardiectomy. It has been reported that a more widely formed pericardial window cup could cause clotting from this hole (10). In this study, a 3x3 cm pericardial window was opened in a Miniature Pinscher. Due to the small size of the Miniature Pinscher, a small window size was preferred to prevent herniation of the heart. In the other 19 dogs, a pericardial window 4 x 4cm was opened and recurrence was only seen in one dog, which was attributed to adhesions having closed the opened window. However, there were no histopathological findings to support this theory.

Recent studies have claimed subphrenic pericardiectomy facilitates thinning of the heart surface and prolongs life compared to partial pericardiectomy (6, 7). In another study, classic open thoracotomies (intercostal, median sternotomy) and thoracoscopic pericardiectomy methods (subtotal (subphrenic) partial) were compared in respect of pain, survival time, length of stay in the hospital, and wound management. Thoracoscopic subphrenic pericardiectomy has proven to be the most advantageous method (20). In the current study, the partial pericardiectomy method was preferred due to a lack of experience of the with subphrenic method.

Walsh et al. (26), reported that thoracoscopic partial pericardiectomy has several advantages compared with open thoracotomy including less pain and shorter recovery time. In the current study, all except one dog were discharged from the hospital after 24 hours and no pain or respiratory distress was seen. Some cases (nos. 8, 15, 16) had a VATS time of 117.5 minutes. A study by Burton (5) reported open surgery time as 109 minutes. In this study, the mean VATS time was 40 minutes, which was much shorter than open surgery times stated in other studies. This period could be shortened with practice.

It has been reported that scar complications at the thoracoscope entry site, phrenic nerve damage, lung lacerations and intraoperative bleeding can be seen as complications of thoracoscopy (14). Case et al. (7) reported that fatal hypotension occurred in 2 of 36 dogs. In this current study, lung laceration occurred during thoracic entry in only one case, a Miniature Pinscher dog (case 5), and that case was converted to open surgery. It was concluded that in small breed dogs, pneumothorax must be ensured before starting thoracoscopic surgery.

To understand whether or not thoracic valves are in the pleural cavity, the valve must be removed. The pulmonary automatic ventilation device should be inflated as little as possible.

A high recurrence rate has been reported in the pericardiocentesis procedure alone. Surgical pericardial windowing offer the best long-term results minimizing pericardial effusion recurrence (14, 21). Of the 20 dogs included in this study, no recurrence occurred in 19 (96%) throughout one year. Case number 20 had recurrent pericardial effusion at 8 months after the procedure and the patient died that day. In one case (case number 9) hypotension and respiratory distress occurred but did not become fatal. In one study, a dog with similar symptoms was euthanized because it did not improve with medical treatment (2).

Brisson et al. (4), reported that in a patient with mesothelioma, metastases occurred in the thoracic entry site. in the current study, (case number 3), pericardial effusion had developed because of rhabdomyosarcoma but no metastasis or recurrence was seen. However, in pericardial effusions of neoplastic origin, metastases can be expected because effusion opens and drains from the thoracic cavity. Modified pericardiectomy procedures should be developed to minimize the risk of metastasis in these kinds of patients. In this case pulmonary metastatic areas were seen on the postoperative 3rd month

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radiography and the patient died at 4 months postoperatively due to severe respiratory problems. Hartmann et al. (11) reported that a cardiac mass was not observed on ultrasonography but the mass was subsequently observed on thoracoscopic examination. In the current study, a rhabdomyosarcoma mass was not seen on ultrasonography but was detected later on thoracoscopic examination. Both of these studies demonstrate thoracoscopy is a superior method for the visualization of mass lesions causing pericardial effusion.

In the current study, the tumoral formation (rhabdomyosarcoma) in one case that could not be seen on echocardiography was able to be visualized during the partial pericardiectomy. This can be considered fortunate because the tumor localization could be seen from the site where the pericardial window was opened. As stated by Carvajal et al (6), this proved that if the partial pericardiectomy method is to be applied to a patient, a detailed evaluation of the pericardial/epicardial surface with pericardioscopy is necessary.

Dogs with presumptive idiopathic pericardial effusion treated with a subtotal pericardiectomy via thoracotomy have been shown to have longer median survival times (MST) compared with dogs treated with a thoracoscopic pericardial window. The discrepancy in long-term outcomes between surgical techniques has been suggested to be the result of non-durable decompression of the pericardial space for dogs with chronic effusion, and the inaccuracy of the initial diagnosis, possibly because of the limited visualization of gross pericardial/epicardial pathology provided by the method of choice (6).

For dogs with presumptive idiopathic pericardial effusion applied with the pericardial window technique, McCarthy (20) and Walsh et al. (26) performed pericardiectomy with the patients in lateral recumbence. In the current study, dorsal recumbence was preferred as it increased the field of vision, and facilitated pericardial incision and dissection because the lung stayed in the dorsal field because of gravity.

In patients where the para-xiphoid trans-diaphragmatic approach was used, the heart was seen in angulation and the desired area could be easily reached by advancing the thoracoscopic tools from the left and right intercostal segments. Visualization of the thoracic cavity and the use of thoracoscopic instruments in the intercostal approach in small breed patients may be difficult. The authors believe that depending on the experience of the surgeon, the paraxiphoid-transdiaphragmatic approach is more useful in small animals. Balsa (3) suggested that pericardiocentesis should be performed in small dogs with severe pericardial effusion to provide a comfortable field of vision before thoracoscopy, and the same result was reached in this study.

From our experience, the paraxiphoid trans-diaphragmatic technique provides a more comfortable visual angle and the movements of the thoracoscopic manual instruments can be followed more easily from this visualization. In the intercostal approach, the visual window is narrow, but manual instrument-camera coordination can be made more easily. With further studies, the operation time may be shortened. From the experience of this study, it was concluded that the ease of working in both techniques was completely operator-dependent.

In conclusion, this study showed that thoracoscopic partial pericardiectomy for the treatment of pericardial effusion is very successful in dogs. Because thoracoscopic partial pericardiectomy is a minimally invasive procedure, it causes less pain and has a shorter recovery time. This could also be the first step for thoracoscopic subtotal pericardiectomy, which has better results than this method, both for the patient and surgeon.

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Conflict of Interests

The authors have no conflict of interests to declare.

Author Contributions

YŞ, AB and BBÖ operated and evaluated the patients with the technique mentioned in the article. OOŞ determined the anesthesia protocol of the application and managed the anesthesia and pain relief aspect of his patients. AEH took part in the diagnosis and surgical referral of pericardial effusion. YŞ and İB did the image recording of the patients, the drafting of the publication and the English translation of the article. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Statement

This study was conducted with the approval of the Animal Experiments and Local Ethics Committee of Ankara University, decision numbered 2008-31-143.

Animal Welfare

The authors confirm that they have adhered to ARRIVE Guidelines to protect animals used for scientific purposes.

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